Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2018

Course Code: CH204

Course Name: CHEMICAL ENGINEERING THERMODYNAMICS (CH)

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any two question, each carries 15 marks Marks

1	a)	Define extensive and intensive properties with suitable examples.	(2)
	b)	Write down the fundamental property relations and Maxwell's equations.	(3)
	c)	Starting from first law of thermodynamics, derive expression for maximum velocity attained by a fluid flowing through a pipe. State assumptions clearly.	(5)
	d)	Explain any two methods for determining fugacity coefficient of a pure gas.	(5)
2	a)	State the limitations of first law of Thermodynamics.	(2)
	b)	Define activity and mention its application.	(3)
	c)	Obtain expression for the change in internal energy, enthalpy and entropy, heat added and work done in an isothermal process involving an ideal gas.	(5)
	d)	Derive an expression for fugacity coefficient of a gas obeying the equation of state $Z = a+bP+cP^2$	(5)
3	a)	State the zeroth law of thermodynamics and explain its application in temperature measurement.	(5)
	b)	Explain with a schematic diagram the features of the absorption refrigeration cycle. How it is different from the vapour compression refrigeration cycle?	(5)
	c)	The coefficient of volume expansion of water at 373 K is 7.8×10^{-4} K^{-1}. Calculate the change in entropy when the pressure is increased from 1 bar to 100 bar. At 373 K, density of water is 958 kg/m^3. State the assumptions, if any.	(5)

PART B

Answer any two question, each carries 15 marks

4	a)	State phase rule for non-reacting systems and Duhem's theorem.	(2)
	b)	Explain the principle of azeotrope formation with suitable example.	(3)
	c)	Define chemical potential. State its significance in thermodynamics.	(5)
	d)	Explain the Redlich-Kister method for testing consistency of VLE data.	(5)
5	a)	State Raoult's law. Differentiate between ideal and non-idealsolutions.	(5)
	b)	Derive an expression for the phase equilibrium in single component systems	(5)
	c)	An equimolar solution of A and B is totally vaporised at a constant temperature of 370 K. at this temperature, the vapour pressures of A and B are 166.2 and 70 kPa respectively. What are the pressures at the beginning and at the end of the vaporisation process?	(5)
6	a)	Define activity coefficient. What is the effect of temperature on activity coefficient?	(5)
	b)	Derive, from the definition of partial molar property,the Gibbs Duhem Equation in terms of activity coefficient and list its applications in solution thermodynamics.	(5)
	c)	Apply the van Laar equation to calculate the activity coefficients in a solution of	(5)

components A and B containing 12% (mol) of A. Given that the components form an azeotropic mixture at 345 K and 101.3 kPa with 45% (mol) of A. At 345 K the vapour pressures of A and B are 71.2 and 73.8 kPa respectively. Specify the assumptions, if any.

PART C

Answer any two question, each carries 20 marks

7 a) i) Differentiate between type I and type II VLE with the help of equilibrium diagrams. (3)

ii) Define reaction coordinate. How is it related to the equilibrium conversion? (3)

b) Explain with a neat sketch the VLE for a system of two immiscible liquids. (4)

c) Define critical solution temperature. What does a tie line in the binodal solubility curve represent? (3)

d) i) Obtain expression for overall equilibrium constant for the simultaneous reactions having equilibrium constants K_1 and K_2. (3)

ii) A reaction mixture of steam and ethylene in the molar ratio 1:2 undergoes the following reaction at 398 K and 1 bar. $C_2H_2(g) + H_2O(g) \rightarrow C_2H_5OH(g)$ (4)

Calculate the equilibrium conversion if the standard free energy change for this reaction is 1175 J/mol at 398 K.

8 a) Illustrate with a neat sketch, how a ternary liquid equilibrium is represented using triangular coordinates. (3)

b) Explain the term 'Pressure of decomposition' using suitable example. (3)

c) With neat phase diagram and distribution diagram, explain the features of the VLE of two partially miscible liquids. (7)

d) Ammonia synthesis reaction is carried out with nitrogen and hydrogen in 2:3 molar ratio as the reactor feed. The equilibrium constant for the reaction at 700 K may be taken as 2.3 x 10^{-4}. Determine the percentage conversion of Nitrogen to Ammonia at 700K and 15 bar. What would be the conversion at 700K and 150 bar? Compare the values and justify. (7)

9 a) A liquid mixture of components A (44% mole), B (28% mole) and C (28% mole) is vapourised at a total pressure of 101.33 kPa. Calculate i) the bubble point and the vapour composition ii) the dew point and the liquid composition. State the assumptions, if any. The vapour pressure data is as given below: (10)

Temperature K	333	343	353	363
P_A^S, kPa	81.97	133.29	186.61	266.58
P_B^S, kPa	49.32	73.31	106.63	166.61
P_A^S, kPa	39.32	62.65	93.30	133.29

b) Point out the effect of temperature and pressure on the equilibrium constant and the equilibrium conversion of a chemical reaction. (6)

c) A system of reaction mixture consists of CO, CO_2, H_2, H_2O and CH_4. How many independent variables are to be defined to describe this system completely at equilibrium. (4)

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